Appendix G: Pollutant Load Methodology & Flow and Load Duration Results

SWAMM™ Results & Methodology

Spatial Watershed Assessment & Management Model

Des Plaines River Watershed

Illinois, Wisconsin

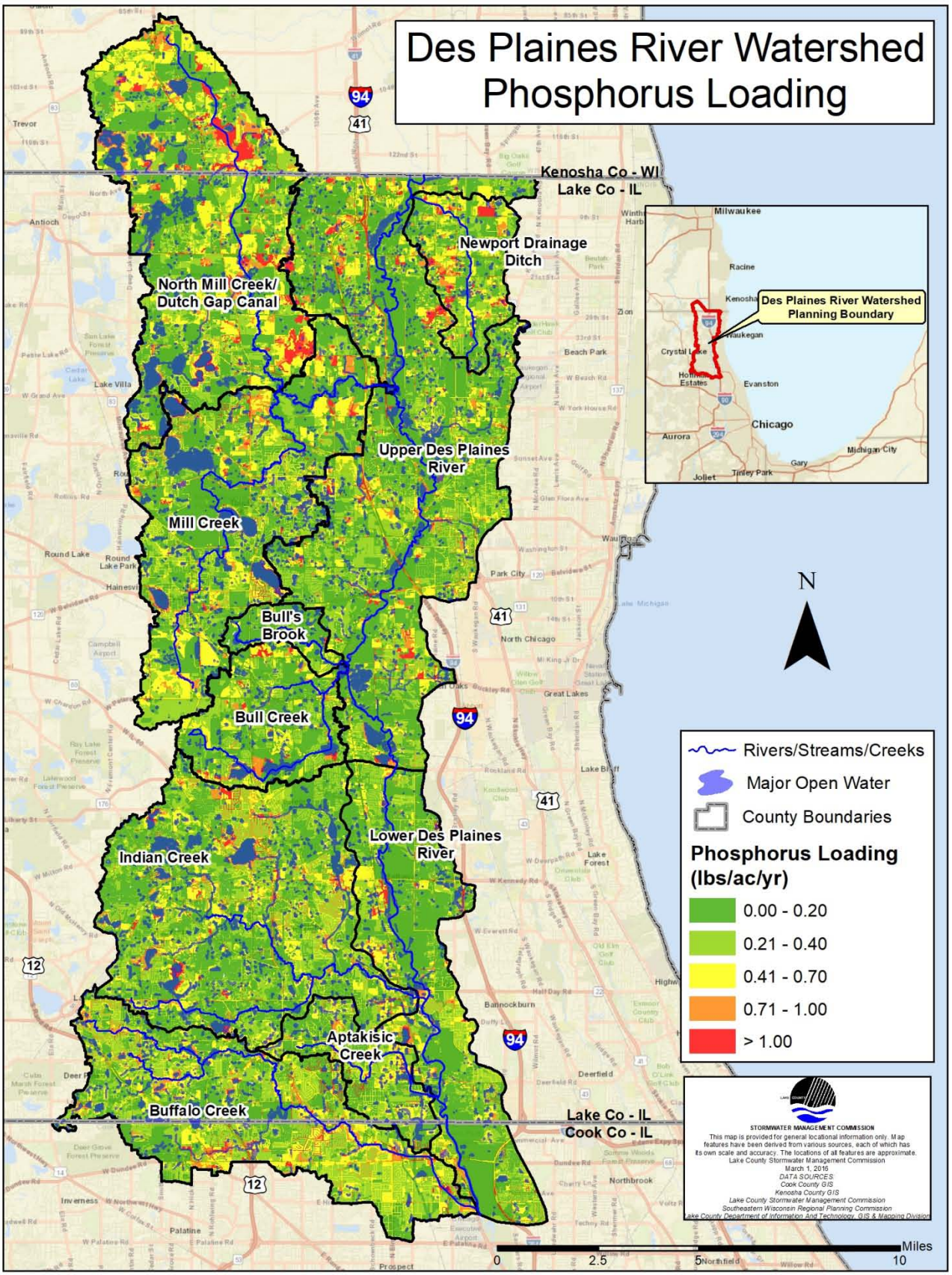
Prepared By:
Northwater Consulting
For:
Lake County Stormwater management Commission (LCSMC)

February, 2018

Table of Contents

Tables and Figures

Figure 1 - Model Extent; Location Map



SWAMM™ Methodology

1.0 Introduction

A customized SWAMM™ (Spatial Watershed Assessment and Management Model) was developed for the Des Plaines River Watershed for both current and future landuse. The custom model estimates parcel level pollutant loading of Total Nitrogen (TN), Total Phosphorus (TP), Sediment (TSS), Chloride (Cl) and Fecal Coliform Bacteria. This paper summarizes the results and methodology of the model.

The model is built using custom GIS data layers and existing public data layers that encompass soils, landuse, and climate. Model results are aggregated into individual units of pollution loading based on landuse, parcel boundaries and soil types. A series of industry standard equations are built into the model to estimate runoff, soil erosion, delivery ratios and ultimately estimate total nonpoint-source pollutant loading of the selected parameters. For this model, Northwater worked directly with SMC to compile Event Mean Concentration (EMC) values for different land uses, which were incorporated into the model.

The model was calibrated to acceptable ranges by comparing USGS gauge data and DRWW monitoring results for the watershed. Climate data from 1980 through 2016 were used to generate rainfall statistics for the model.

The model results can be analyzed by subwatershed, catchments, and landuse. Results can also be analyzed based on user defined boundaries and presented in map format, easily overlaid on existing base maps. The model includes 191,905 unique records for current landuse and 69,651 unique records for future landuse from which pollution loading is analyzed.

2.0 SWAMM™ Methodology

The custom SWAMM™ model consists of two primary components:

- Universal Soil Loss Equation (USLE) Component
- Event Mean Concentration (EMC) Component

2.1 Universal Soil Loss Equation (USLE) Component

The overall analysis methodology was modified by Northwater from:

> *Mitasova and Lubos Mitas: Modeling soil detachment with RUSLE3d using GIS, 1999; University of Illinois. http:/skagit.meas.ncsu.edu/~helena/gmslab/erosion/usle.html*

The USLE component of the model was applied to agricultural land uses within the watershed. The USLE methodology incorporated into the model is summarized below:

- 1:24,000 NRCS Soil Survey Geographic Database (SSURGO) Digital Soils.
- Selected appropriate soil types and relevant USLE factors identified and calculated from SSURGO soils dataset.

Table 1 - USLE Parameters

USLE EQUATION: Annual Soil Loss = LS □ K □C □ R □ P

Land Use	C factor	K factor	LS factor	R factor	P factor
Row Crops	Spring-Till/Mulch-Till/Reduced-Till = 0.25 Alfalfa/Wheat = 0.02 No-Till = 0.12 Strip-Till = 0.16 No-Till with Cover Crops = 0.04 Hay = 0.01 Conventional-Till = 0.42 0.18 used for all future landuse (watershed average)	Values included in SSURGO tabular data	SSURGO tabular data; calculated from slope and slope length values or from local NRCS	140	0.5-1 0.82 used for all future landuse (watershed average)

2.2 Event Mean Concentration (EMC) Component

All formulas and selected variables were derived from: *STEPL (Spreadsheet Tool for Estimation of Pollutant Load) Version 3, Tetra Tech, 2004.*

EMC values and runoff curve numbers were derived from several sources, which are annotated in section 5.0.

Bacteria

For Bacteria, Schueler's Simple Method (1987) was modified for estimating bacterial loads.

Precipitation

Annual precipitation, number of rain days and correction factors were determined using the Elgin and Antioch weather stations. A period of 36 years was used (1980-2016) to determine the parameters outlined in Table 3:

Table 2 – Rainfall Factors

Average Number of Rain Days	Rain Days Correction Factor	Average P Value (inches)
112.81	**0.434**	**0.65**

Delivery Ratio

A distance based delivery ratio was applied to soil, based on:

Minnesota Board of Water & Soil Resources, Pollution Reduction Estimator Water Erosion - Microsoft Excel® Version September 2010.

Delivery Ratio = Polygon Distance from Stream ^$^{-0.2069}$

Table 3 - Model Parameters

Model	Rain days	Correction Factor (precipitation and rain days)	Curve Number (by soil hydrologic group)	Runoff (by soil hydrologic group in inches)	EMC for N, P, Chloride, TSS, Bacteria
All landuse	see Table 2 above	see Table 2 above	see Table 4 below	Calculated using the following equation: $Q = \frac{((P - (IaXS))^{\wedge 2}}{P + 0.8 X S}$ $S = \frac{1000}{CN} - 10$ Q = Runoff (inches) P = Precipitation (inches) S = Potential max retention (inches) CN = Curve Number Ia = Initial abstraction factor; set to 0 for annual runoff	see Table 4 below

Table 4 - Event Mean Concentrations & Curve Numbers; Current Landuse

Landuse Category	EMC Chloride (mg/l)	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Bacteria (counts/ 100ml)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
Airport (High)	300	2.3	0.34	153	1700	89	92	94	95
Airport (Medium)	300	2.3	0.34	153	1700	77	85	90	92
Beaches	0.91	2.5	0.2	30	3846	63	N/A	N/A	N/A
Bus Facility (Very High)	200	2.3	0.34	240	1400	96	96	96	96
Bus Facility (Medium)	148	2.3	0.34	240	1400	81	88	91	93
Cemetery (High)	148	3.1	0.46	84	1400	68	79	86	89
Cemetery (Medium)	148	3.1	0.46	84	1400	49	69	79	84
Cemetery (Low)	74	3.1	0.46	84	1400	39	61	74	80
Commercial/Retail (Very High)	250	3	0.42	206	1800	96	96	96	96
Commercial/Retail (High)	250	3	0.42	206	1800	89	92	94	95
Commercial/Retail (Medium)	148	3	0.4	153	1400	77	85	90	92
Commercial/Retail (low)	148	2.8	0.4	153	1400	61	75	83	87
Cultural and Entertainment (Very High)	148	2.16	0.3	206	1800	96	96	96	96
Cultural and Entertainment (High)	148	2.16	0.3	206	1800	89	92	94	95
Cultural and Entertainment (Medium)	148	1.3	0.29	153	1400	77	85	90	92
Cultural and Entertainment (Low)	148	1.3	0.29	153	1400	61	75	83	87
Equestrian Pasture (Very High)	0.91	13.5	2.6	390	36000	77	86	91	94
Equestrian Pasture (High)	0.91	10.1	1.5	300	22000	75	84	89	91
Equestrian Pasture (Medium)	0.91	6	0.6	150	13000	57	72	81	86
Equestrian Pasture (Low)	0.91	3.6	0.36	70	10500	39	61	74	80
Farm Building (Very High)	71	7.1	0.45	240	9000	96	96	96	96
Farm Building (High)	71	7.1	0.45	240	9000	81	88	91	93
Farm Building (Medium)	15	6.8	0.42	160	8400	61	75	83	87
Farm Building (Low)	15	6.8	0.33	72	8400	51	68	79	84

Landuse Category	EMC Chloride (mg/l)	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Bacteria (counts/ 100ml)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
Feed Lot (High)	0.91	13.5	2.6	390	36000	77	86	91	94
Feed Lot (Medium)	0.91	10.1	1.5	280	13000	76	85	90	93
Feed Lot (Low)	0.91	6.75	0.75	240	10500	68	79	86	89
Forest	0.91	1.4	0.15	30	1000	30	55	70	77
Golf Courses	0.91	3.6	0.6	84	2600	76	79	80	81
Government/Institutional (Very High)	148	3.2	0.42	206	1800	96	96	96	96
Government/Institutional (High)	148	3.2	0.42	206	1800	89	92	94	95
Government/Institutional (Medium)	148	3	0.4	153	1400	77	85	90	92
Government/Institutional (Low)	148	2.8	0.4	153	1400	61	75	83	87
Grassland	0.91	0.7	0.13	15	1000	39	61	74	80
Hotel/Motel (Very High)	148	3	0.42	206	2500	96	96	96	96
Hotel/Motel (High)	148	3	0.42	206	2500	89	92	94	95
Industrial (Very High)	148	2.4	0.31	230	2500	96	96	96	96
Industrial (High)	148	2.4	0.31	230	2500	89	92	94	95
Industrial (Medium)	148	2.2	0.31	215	2300	81	88	91	93
Industrial (Low)	148	2	0.29	153	1400	61	75	83	87
Junk Yard (High)	148	2.6	0.31	300	2500	72	80	85	87
Junk Yard (Medium)	148	2.6	0.31	300	2500	61	75	83	87
Landfill	148	2.6	0.31	230	2500	81	88	91	93
Mobile Homes (Very High)	50	3.3	0.4	153	8700	81	88	91	93
Mobile Homes (High)	50	3.3	0.4	153	8700	77	85	90	92
Mobile Homes (Medium)	50	3.2	0.39	150	8700	61	75	83	87
Office/Research (Very High)	148	3.2	0.42	153	1400	96	96	96	96
Office/Research (High)	148	3.2	0.42	153	1400	89	92	94	95
Open Space Road	15	3.6	0.7	84	1000	39	61	74	80
Open Water	120	0.375	0.025	1.5	276	100	100	100	100
Stream	70	1.25	0.11	3.1	500	100	100	100	100
Orchards and Nurseries	0.91	6.8	0.42	160	5200	51	68	79	84
Other Conservation	0.91	0.7	0.15	15	1000	35	58	72	79
Other Open Space	0.91	1.4	0.15	30	1000	30	55	70	77
Parking Lot	250	2.3	0.34	153	1700	98	98	98	98
Parks and Recreation (Very High)	15	2.5	0.2	30	1000	72	80	85	87
Parks and Recreation (High)	15	2.5	0.2	30	1000	68	79	86	89
Parks and Recreation (Medium)	15	2.5	0.2	30	1000	49	69	79	84
Parks and Recreation (Low)	0.91	2.5	0.2	30	1000	39	61	74	80
Pasture (Very High)	0.91	13.5	2.6	390	36000	77	86	91	94
Pasture (High)	0.91	10.1	1.5	300	22000	75	84	89	91
Pasture (Medium)	0.91	6	0.6	150	13000	57	72	81	86
Pasture (Low)	0.91	3.6	0.36	70	10500	39	61	74	80
Rail Station (Very High)	148	2.3	0.34	240	1400	96	96	96	96
Rail Station (High)	148	2.3	0.34	240	1400	89	92	94	95
Rail Station (Medium)	148	2.3	0.34	120	1400	77	85	90	92
Railroad	148	2	0.34	240	1700	89	89	89	89

Landuse Category	EMC Chloride (mg/l)	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Bacteria (counts/ 100ml)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
Recreational Trails	15	2.5	0.15	72	1000	85	85	85	85
Residential Multi-Family (Medium)	148	3.2	0.3	153	8400	61	75	83	87
Residential Multi-Family (Low)	148	3.2	0.3	73	8300	54	70	80	85
Residential Single-Family (Very High)	148	3.2	0.3	206	8400	94	94	94	94
Residential Single-Family (High)	148	3.2	0.3	206	8400	81	88	91	93
Residential Single-Family (Medium)	148	3.2	0.3	153	8400	61	75	83	87
Residential Single-Family (Low)	148	3.2	0.3	73	8300	54	70	80	85
Residential Farm (Very High)	74	3.3	0.32	260	10500	81	88	91	93
Residential Farm (High)	74	3.3	0.32	260	10500	77	85	90	92
Residential Farm (Medium)	74	3.3	0.32	130	10500	61	75	83	87
Residential Farm (Low)	74	3.3	0.32	65	10500	51	68	79	84
Under Development	15	1.3	0.18	153	1300	77	85	91	94
Roads	300	2.3	0.34	153	1700	98	98	98	98
Row Crops (Conventional Tillage)	0.91	7.1	0.6	N/A	2600	72	81	88	91
Row Crops (Spring Till/Reduced-Till)	0.91	7.1	0.6	N/A	2600	71	80	87	90
Row Crops (No Till)	0.91	6	0.5	N/A	2600	67	78	85	89
Row Crops (No Till and Cover Crop)	0.91	5	0.42	N/A	2600	64	75	82	85
Row Crops (Wheat)	0.91	5	0.42	N/A	2600	65	76	84	88
Row Crops (Hay)	0.91	2.5	0.2	N/A	2600	39	58	71	78
Row Crop with Nutrient Management Plan	-	4.5	0.275	-	-	-	-	-	-
Urban Open Space	0.91	2.5	0.15	30	1000	49	69	79	84
Utilities (Very High)	148	2.1	0.34	153	1400	96	96	96	96
Utilities (High)	148	2.1	0.34	153	1400	89	92	94	95
Utilities (Medium)	148	2.1	0.3	77	1400	77	85	90	92
Utilities (Low)	148	1.3	0.3	65	1400	57	72	81	86
Utility ROW	0.91	2.5	0.15	30	1000	39	61	74	80
Vacant	0.91	1.3	0.15	30	1000	34	57	72	78
Vehicle Dealership (Very High)	250	3	0.42	206	1400	96	96	96	96
Vehicle Dealership (High)	250	3	0.42	206	1400	89	92	94	95
Vehicle Dealership (Medium)	148	3	0.4	153	1200	77	85	90	92
Vehicle Dealership (Low)	148	2.8	0.4	153	1200	61	75	83	87
Warehousing (Very High)	148	2.6	0.4	206	2300	96	96	96	96
Warehousing (High)	148	2.6	0.4	206	2300	92	93	94	95
Warehousing (Medium)	148	2.6	0.4	153	2200	77	85	90	92
Warehousing (Low)	148	1.3	0.3	65	1400	61	75	83	87
Wetlands	0.91	0.7	0.19	10.2	500	38	60	74	80

Table 5 - Event Mean Concentrations & Curve Numbers; Future Landuse

Landuse Category	EMC Chloride (mg/l)	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Bacteria (counts/ 100ml)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
Agricultural	0.91	7.1	0.6	N/A*	2600	71	80	87	90
Government/Institutional	148	3.2	0.42	206	1800	89	92	94	95
Industrial	148	2.4	0.31	230	2500	89	92	94	95
Mixed Use/General	148	3	0.42	153	1400	77	85	90	92
Residential	148	3.2	0.3	153	8400	81	88	91	93
Office and Research Parks	148	3.2	0.42	153	1800	89	92	94	95
Public/Private Open Space	15	2.5	0.2	30	1000	49	69	79	84
Low Residential with Sewer	113	2.6	0.24	51	7055	54	70	80	85
Retail/Commercial	250	3	0.42	206	1800	89	92	94	95
Vacant	0.91	1.3	0.15	30	1000	34	57	72	78
Medium Density Urban	148	3.2	0.3	153	8400	61	75	83	87
Low Density Urban	148	3.2	0.3	153	8400	51	68	79	84
Utility/Transport	148	2.1	0.34	153	1400	89	92	94	95
Gateway	148	3.2	0.42	153	1800	69	79	86	89
Water	120	0.375	0.025	1.5	276	100	100	100	100

3.0 Model Calibration

The model was calibrated using a load duration analysis based on USGS gauge data and DRWW monitoring results. Average per acre loading data from several regionally-derived plans, publications, and other documents was also utilized. Calibration was performed for:

1. Quality Assurance / Quality Control – to find and correct user errors in the model scripts and algorithms.
2. To evaluate whether stream-flow (runoff) and pollutant loading were in the correct ranges based on existing data analysis and literature.
3. To calibrate model by adjusting parameters so that cumulative model results represent regional averages.

The model is estimating accumulated/delivered pollutant loading, represented mostly in the literature. Important notes on the model include:

- The model does not directly account for point-source pollution.
- The model estimates annual pollutant mobilization from individual parcels of land and does not take into account storage, fate, and transport watershed processes.
- The model accounts for precipitation runoff; but not base flow, point source discharges or drainage-tile contributions.

A total 2 calibration runs were performed on the initial model results. For the first calibration run, the existing detention correction (see section 5.0) was decreased for TSS and TP; all TN and Cl EMC's were doubled. For the second and final calibration run, the existing detention correction (see section 5.0) was decreased slightly for TN and Cl.

4.0 Bibliography of EMC Literature

1. *Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) Technical Guide, Version 1.0 Release 1, November 2004.*
2. *Lower DuPage River Watershed Plan Pollution Load Model Methodology, 2010.*
3. *Cotton-Mutton Creek, Slocum Lake Drain/Fiddle Creek, and Tower Lakes Drain Watershed Pollution Load Model Methodology, Northwater Consulting, 2013.*
4. *North Mill Creek-Dutch Gap Canal Watershed-Based Plan, Pollutant Load Model Methodology, 2011.*
5. *Price, Thomas H., 1993. Unit Area Pollutant Load Estimates for Lake County Illinois Lake Michigan Watersheds.*
6. *Todd D. Stuntebeck, Matthew J. Komiskey, Marie C. Peppler, David W. Owens, and Dennis R. Frame 2011. Precipitation-Runoff Relations and Water-Quality Characteristics at Edge-of-Field. Stations, Discovery Farms and Pioneer Farm, Wisconsin, 2003–08.*
7. *Walton R. Kelly, Samuel V. Panno, Keith Hackley, 2012. The Sources, Distribution, and Trends of Chloride in the Waters of Illinois.*
8. *Robert Pitt, Alex Maestre, and Renee Morquecho, 2004. The National Stormwater Quality Database (NSQD, version 1.1).*
9. *Holly Hudson, Chicago Metropolitan Agency for Planning, April 2013 (e-mail:* hhudson@cmap.illinois.gov*; ph: 312-386-8700).*
10. *Adam, M., M. Colwell, C.L. Sanders, J. Wudi, and M. Pfister. 2005. 2004 Summary Report of Woodland (Highland) Lake. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/WoodlandLake.pdf (accessed Feb. 2013)*
11. *Brant, C.L., M. Colwell, M. Adam, J. Marencik, and M. Pfister. 2005. 2003 Summary Report of Island Lake. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/Island%20Report.pdf (accessed Feb. 2013)*
12. *Brune, G.M. 1953. Trap efficiency of reservoirs. Transactions American Geophysical Union 34(3):407-18.*
13. *Davis, A., M. Adam, L. Dane, and S. Keseley. Undated. 2005 Summary Report of Slocum Lake. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/Slocum05.pdf (accessed Feb. 2013)*
14. *Deem, K., M. Adam, L. Dane, and K. Paap. Undated. 2008 Summary Report of Bangs Lake. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/Bangs08.pdf (accessed Feb. 2013)*
15. *Deem, K., M. Adam, L. Dane, and K. Paap. Undated. 2009 Summary Report of Ozaukee Lake. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/Ozaukee%2009.pdf (accessed Feb. 2013)*
16. *Deem, K., M. Adam, L. Dane, and K. Paap. Undated. 2009 Summary Report of Lake Napa Suwe. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/NapaSuwe%202009.pdf (accessed Feb. 2013)*
17. *Kelly, W.R, S.V. Panno, and K. Hackley. 2012. The Sources, Distribution, and Trends of Chloride in the Waters of Illinois. Illinois State Water Survey Bulletin B-74, 59 pp., Champaign. http://www.isws.illinois.edu/pubdoc/B/ISWSB-74.pdf (accessed Feb. 2013)*
18. *Keseley, S., M. Adam, L. Dane, and A. Orr. Undated. 2007 Summary Report of Lake Fairview. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/2007Fairview.pdf* http://health.lakecountyil.gov/Population/LMU/Lakes/Slocum05.pdf *(accessed Feb. 2013)*
19. *Keseley, S., M. Adam, L. Dane, and A. Orr. Undated. 2007 Summary Report of Timber Lake. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/2007Timber(S).pdf*http://health.lakecountyil.gov/Population/LMU/Lakes/Slocum05.pdf *(accessed Feb. 2013)*
20. *Müller, B. and R. Gächter. 2012. Increasing chloride concentrations in Lake Constance: characterization of sources and estimation of loads. Aquatic Sciences 74(1):101-112. http://www.eawag.ch/forschung/surf/publikationen/2011/2011_mueller.pdf (accessed Feb. 2013)*
21. *Novotny, E.V., D. Murphy, and H.G. Stefan. 2008. Increase of urban lake salinity by road deicing salt. Science of the Total Environment 406(2008):131-144. http://dx.doi.org/10.1016/j.scitotenv.2008.07.037;*

http://www.geology.wmich.edu/Koretsky/EnvironmentalGeochemistry/Novotny2008.pdf (accessed Feb. 2013)

22. *Novotny, E., A. Sander, O. Mohseni, and H. Stefan. 2008. A Salt (Chloride) Balance for the Minneapolis/St. Paul Metropolitan Area Environment. Project Report No. 513. Prepared by Univ. of Minnesota St. Anthony Falls Laboratory for Local Research Board, Minnesota Dept. of Transportation. St. Paul. http://conservancy.umn.edu/bitstream/115339/1/pr513.pdf (accessed Feb. 2013*
23. *Orr, A., M. Adam, L. Dane, and S. Keseley. Undated. 2007 Summary Report of Lake Barrington. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/2007Barrington.pdf* http://health.lakecountyil.gov/Population/LMU/Lakes/Slocum05.pdf*(accessed Feb. 2013)*
24. *Orr, A., M. Adam, L. Dane, and S. Keseley. Undated. 2007 Summary Report of Tower Lake. Lake Co. Health Dept., Libertyville, IL. http://health.lakecountyil.gov/Population/LMU/Lakes/2007Tower.pdf* http://health.lakecountyil.gov/Population/LMU/Lakes/Slocum05.pdf*(accessed Feb. 2013)*
25. *Striegl, R.G. and E.A. Cowan. 1987. Relations between Quality of Urban Runoff and Quality of Lake Ellyn at Glen Ellyn, Illinois. USGS Water-Supply Paper 2301. U.S. Gov't Printing Office, Denver, CO. http://pubs.usgs.gov/wsp/2301/report.pdf (accessed Feb. 2013)*

5.0 Supplemental Model Notes & Output GIS Metadata

1. The most current landuse data were used. Landuse data were modified to represent a hybrid landuse/landcover layer by interpreting recent aerial imagery, digitizing/labeling polygons and reclassifying existing land use categories. Additional information was appended to the landuse to represent type of row crops tillage. Where applicable, many landuse categories were modified and classified into very high, high, medium, and low density.
2. Individual locations were coded as detained if they drained to an existing retention/detention basin and a correction factor was applied and adjusted during the calibration phase.
3. EMC values for nitrogen and phosphorus were reduced if a farm field was known to have a Nutrient Management Plan.
4. Individual site adjustments were made if a known or previously implemented BMP was identified.
5. Equestrian and pasture areas were further delineated to represent living quarters/buildings and dry/concentrated feeding areas versus grazing or grass areas. These areas were classified into very high, high, medium, and low based on pasture quality based on a field assessment or an interpretation of aerial imagery.
6. The stream/waterbody file used to run proximity calculations for the purposes of determining a delivery ratio was modified using a National Hydrography Dataset (NHD) file and a streams and lake file provided by the Lake County Stormwater Management Commission representing linear water features and the outer boundary of water feature areas (e.g., lakes and ponds). These stream and lake files were combined into one GIS file, overlaid on aerial imagery and edited to ensure they represent actual watershed features. This line file represents lake, pond, and lagoon outlines and perennial and intermittent stream centerlines.

NORTHWATER CONSULTING

FLOW & LOAD DURATION RESULTS – DES PLAINES

The results of the flow and load duration analysis was performed at five USGS gaging stations using 2015, 2016, and 2016 DRWW water quality monitoring data from relevant stations. Table 1 presents the results, and Table 2 includes the relevant DRWW stations for each USGS station, and notes regarding site selection for analysis.

Table 1 - Flow and Load Analysis For Five USGS Stations in the Des Plaines Watershed

Parameter	Unit	Des Plaines at Russel Road	Des Plaines River near Des Plaines	Des Plaines River Near Gurnee	North Mill Creek Near Milburn	Mill Creek at Old Mill Creek	Buffalo Creek Near Wheeling
		USGS 5527800	USGS 5529000	USGS 5528000	USGS 5527910	USGS 5527950	USGS 5528500
Drainage Area	mi2	123	360	232	28.4	61	19.6
	acres	78,720	230,400	148,480	18,176	39,040	12,544
Water Yield	acre-feet	64,684	302,182	155,128	15,203	36,615	24,112
	cfs	89	417	214	21	51	33
Total Suspended Sediment	tons/yr	749	7,097	2,879	277	1,850	NA
	tons/acre/yr	0.01	0.03	0.02	0.02	0.05	NA
Total Nitrogen	lbs/yr	637,003	3,428,564	1,168,106	*77,270*	210,218	22,646
	lbs/acre/yr	8.09	14.88	7.87	*4.25*	5.38	1.81
Total Phosphorus	lbs/yr	26,322	330,757	93,240	7,044	15,048	6,160
	lbs/acre/yr	0.33	1.44	0.63	0.39	0.39	0.49
Total Chloride	lbs/yr	19,870,216	128,331,083	59,684,511	2,893,034	14,121,776	10,929,756
	lbs/acre/yr	252	557	402	159	362	871
E. Coli	CFU/yr	8.E+13	1.E+15	4.E+14	4.E+13	1.E+14	9.E+13
	CFU/acre/yr	975,836,005	4,603,047,108	2,677,264,540	2,407,559,520	2,567,209,470	7,542,709,868

italic TKN and Ammonia results were unavailable for many samples, thus total nitrogen is likely low as a result

Average water yield based on the 2014 water year
NA - insufficient water quality data was available for analysis
Total suspended sediment is likely lower than actual due to timing and methodology of sample collection

Table 2 - USGS Stations Selected For Analysis with Relevant DRWW Stations

Location	USGS Gage	DRWW Stations	Notes
Des Plaines River at Russel Road	05527800; 123 mi^2 drainage	13-6	Good location to derive an estimate of flow and loading entering from WI along the mainstem
Des Plaines River at Des Plaines	05529000; 360 mi^2 drainage	16-1 and 16-2 are upstream of the gage location and data can be scaled for analysis	Good location to represent downstream end of the study area on the mainstem
Mill Creek at Old Mill Creek	05527950; 61 mi^2 drainage	11-2; 11-1 is downstream and data can potentially be scaled	Subwatershed with a USGS gage and water quality data
Des Plaines River near Gurnee	05528000; 232 mi^2 drainage	13-1; 13-2 and 13-3 are upstream and data can potentially be scaled	Mainstem of Des Plaines midway through the study area
Buffalo Creek near Wheeling	05528500; 19.6 mi^2 drainage	17-2; 17-3 is upstream of gage and reservoir, and will be evaluated for use in analysis	Subwatershed with a USGS gage and water quality data

Streamflow statistics were evaluated for the Des Plaines River at Des Plaines USGS station and determined that the water year of 2014 is representative of an average year over the last 30-years. We applied this water year to perform flow and load duration analyses.

Table 3 - Summary of streamflow statistics for Des Plaines River at Des Plaines USGS gage, and selection of average water year

Statistic	1986-2016	Water Year 2014
Daily Average (cfs)	406	422
Daily Median (cfs)	250	260
Daily Max (cfs)	2689	2400

End of Memorandum